# ROCKAWAY RIVER SEDIMENT ECOLOGICAL ASSESSMENT L.E. CARPENTER AND CO. WHARTON, NEW JERSEY SITE

MARCH 1993



W.O. No.: 06720-008-001

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WESTON MANAGERS DESIGNERS/CONSULTANTS

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# EXECUTIVE SUMMARY

Roy F. Weston, Inc. (WESTON®), on behalf of L.E. Carpenter and Co., conducted an Ecological Assessment of sediment in the Rockaway River. The objective of this ecological assessment was to characterize the Rockaway River environments associated with the former L.E. Carpenter Site in Wharton, New Jersey for the purpose of identifying potential biological impairment.

The structure of the benthic macroinvertebrate community of the Rockaway River was quantified in terms of taxonomic diversity, numerical abundance, and function and evaluated in light of biotic and abiotic environmental variables. Biotic variables included food availability, while abiotic variables included substrate particle size, riparian stability, vegetation and flow characteristics. The study indicated that the chief deterministic factors driving the distribution and abundance of benthic macroinvertebrates in the study area is the quality of the habitat as it relates to resource availability. The structural variations in the Rockaway River benthic macroinvertebrate community were most pronounced downstream of Washington Forge Pond and were primarily due to an increase in suspended planktonic matter released from the pond. At locations progressively further downstream, a shift in taxonomic and functional dominance was observed. Evidence of adverse ecological effects resulting from contaminants detected in the sediment were not observed in the Rockaway River adjacent to the L.E. Carpenter Site or in any portion of the Rockaway River studied. The historical operations on-site and current conditions of the site are not impacting the biological community in the sediment or water environments of the Rockaway River.

# 1.0 INTRODUCTION

## 1.1 Site Background

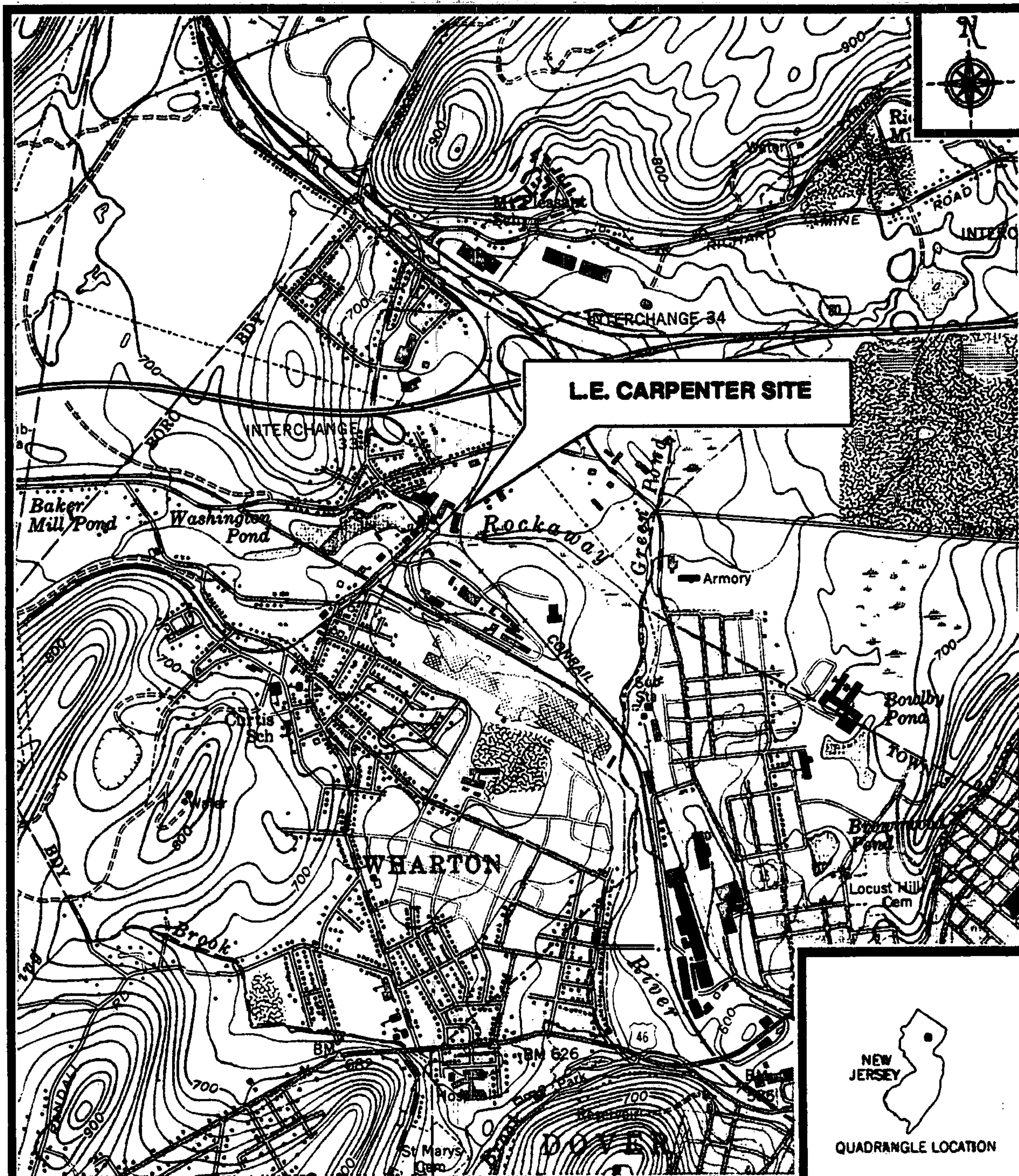
Due to the preliminary nature of the Baseline Ecological Risk Assessment and uncertainties associated with the use of biological effects levels, it was not possible to predict the degree and nature of potential ecological effects associated with the L.E. Carpenter Site. The objective of this ecological assessment was to characterize the Rockaway River environments associated with the L.E. Carpenter Site for the purpose of identifying potential biological impairment. Roy F. Weston Inc. (WESTON®), on behalf of L.E. Carpenter, prepared a Work Plan, completed field and laboratory analyses, and evaluated the data. This report details the results of these activities.

The L.E. Carpenter property is located at 170 North Main Street, Borough of Wharton, Morris County, New Jersey (Figure 1). The property comprises Block 301, Lot 1 and Block 703 Lot 30 on the tax map of the Borough of Wharton. L.E. Carpenter has owned this property since 1943. A vinyl wall covering manufacturing facility was operated on the property from 1943 to 1987. Existing structures are currently utilized as subleased light manufacturing and warehouse space. A detailed description of the site history is provided in the "Revised Report of Remedial Investigation Findings" (June, 1990). A summary of that information is provided in this report.

The site occupies approximately 14.6 acres northeast of the intersection of the Rockaway River and North Main Street and is situated within an industrialized area. The Rockaway River borders the site to the south; a vacant lot lies to the east; and a large compressed gas facility (Air Products Inc.) borders the site to the northeast. Additional industrial facilities are located to the south of the site, adjacent to the Rockaway River. The residential portion of the Borough of Wharton is separated from the site by Ross Street, which is located on the northwestern side of the site.

The site is located within the Dover Mining District, which is one of the oldest mining districts in the country. Iron ore was extracted from three mines in the vicinity of the site from the late 1800's to the early 1900's. The Washington Forge Mine and the West Mount Pleasant Mine were located directly on what is currently the L.E. Carpenter property (Sims, 1958). The Orchard Mine was located on the southern side of the Rockaway River, approximately 200 feet south of the Washington Forge Pond. The Washington Forge and West Mount Pleasant mines operated intermittently between 1868 and 1881. The Orchard Mine was operated intermittently between 1850 and 1910. Tailings from the Washington Forge and West Mount Pleasant mines are thought to have been disposed of on-site.

The L.E. Carpenter facility was involved in the production of vinyl wall coverings from 1943 to 1987. The making of vinyl wall coverings involves several manufacturing processes which were carried out in the various buildings comprising the L.E. Carpenter facility. The first step




Reference: USGS Dover, NJ Quadrangle

SCALE 1:24000

1 ½ 0 1 MILE

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L.E. CARPENTER SITE
WHARTON, NJ.

FIGURE 1
SITE LOCATION MAP

File: LECAR1.DRW

in the process is referred to as lamination. Lamination involves the bonding of fabric to the vinyl film using a plastisol adhesive in conjunction with heat and pressure. The fabric/film laminate is then coated with a plastisol compound in order to texturize the material in preparation for printing. The printing process involves the application of decorative print patterns and/or protective topcoat finishes. When printing is completed, the product is inspected and packaged for shipment to the customer.

The vinyl wall covering manufacturing process involved the discharge of non-contact cooling water to the Rockaway River. During the period of operation, the L.E. Carpenter facility was operated in accordance with prevailing waste disposal regulations and environmental statutes. The facility operated several air pollution control devices permitted by New Jersey Department of Environmental Protection and Energy (NJDEPE) and maintained a New Jersey Pollution Discharge Elimination System (NJPDES) Permit for the discharge of non-contact cooling water.

In response to sampling efforts conducted by the NJDEPE in 1980 and 1981, L.E. Carpenter and NJDEPE entered into an Administrative Consent Order (ACO) on 29 January 1982, which required L.E. Carpenter to remediate waste impoundments and decontaminate groundwater beneath the site. On 24 February 1983, an Addendum (1983, Addendum) was added to the 1982 ACO to clarify its provisions.

Pursuant to the requirements of the 1982 ACO and the 1983 Addendum, L.E. Carpenter took the following actions: In April and May 1982, L.E. Carpenter removed over 4,000 cubic yards of waste from the impoundment; thereafter L.E. Carpenter implemented a groundwater quality monitoring program. On 11 May 1984, L.E. Carpenter also began removing the immiscible chemical compounds from the top of the water table beneath the site.

On 26 September 1986, an additional ACO was entered into which superseded the 29 January 1982 ACO and the Addendum of 24 February 1983 except that all requirements of the Groundwater Decontamination Plan dated 31 October 1983, as approved with conditions by NJDEPE on 26 January 1984, were incorporated. Under the terms of the Amended ACO, effective 26 September 1986, L.E. Carpenter initiated a RI/FS of its former manufacturing facility in Wharton, New Jersey facility.

The active production of vinyl wall covering ceased in 1987. Since that time, the portion of the facility east of the railroad tracks has been inactive and access is currently restricted by an 8-foot chain-link fence. The buildings west of the railroad tracks have been subleased as manufacturing and warehouse space.

## 1.2 Existing Ecological Risk Assessment

Potential ecological effects associated with the L.E. Carpenter Site have been previously estimated (Weston Baseline Ecological Risk Assessment, February, 1992). Exposure of aquatic receptors in the Rockaway River to contaminants of concern were evaluated in concert with toxicological data to estimate the degree of ecological risk. Factors that entered into this assessment included contaminant source locations, local topography and habitat, physical and chemical properties of contaminants, and potential receptors. This evaluation resulted in the development of a conceptual site model which suggested that aquatic organisms are potentially exposed to contaminants at concentrations in excess of biological effects levels. However, the Baseline Ecological Risk Assessment also identified uncertainties associated with the results, underscoring the need for an empirical determination of the biological integrity of the modeled receptors.

## 1.3 Objective

Due to the preliminary nature of the Baseline Ecological Risk Assessment, and uncertainties associated with the use of biological effects levels, it was not possible to predict the degree and nature of potential ecological effects associated with the L.E. Carpenter Site. The objective of this ecological assessment was to characterize the Rockaway River environments associated with the L.E. Carpenter Site for the purpose of identifying potential biological impairment. In addition, the investigation was conducted to satisfy the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 104(b)(2), CERCLA as amended by Superfund Amendments and Reauthorization Act (SARA) Section 122(j)(1) and 122(j)(2), the National Contingency Plan (NCP), and the Resource, Conservation and Recovery Act.

## 2.0 METHODS

### 2.1 Project Scope

On 17 and 18 September 1992, WESTON conducted an ecological assessment of the Rockaway River in the vicinity of the L.E. Carpenter Site, Wharton, New Jersey. Also present on 17 September 1992 were Christina H. Purcell and John Prendergast of the NJDEPE.

Protocols aimed at characterizing the aquatic and riparian habitat and the distribution and abundance of benthic macroinvertebrates were used to collect data. Sampling locations were situated in areas most likely to yield representative specimens of infaunal and benthic macroinvertebrates.

The following tasks were performed:

- *In situ* water quality data collection
- Benthic macroinvertebrate survey
- Aquatic and riparian habitat evaluation

Prior to the field investigation, existing literature, data, and other reports concerning the site were reviewed to determine the appropriate methodologies for site activities. Assessment options were evaluated and potential sampling locations were targeted in cooperation with representatives of the NJDEPE prior to the development of the Work Plan. The Work Plan was submitted to and approved by the NJDEPE on 22 June 1992. Performance of the ecological assessment followed accepted and approved methodology including:

- Rapid Bioassessment Protocols for use in Stream and Rivers, Benthic Macroinvertebrates and Fish (US EPA, 1989)
- Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters (US EPA, 1990)
- IERL-RTP Procedures Manual: Level I Environmental Assessment, Biological Tests (US EPA, 1981)
- Protocol for Bioassessment of Hazardous Waste Sites (US EPA, 1983)
- Review of Ecological Risk Assessment Methods (US EPA, 1988)
- Risk Assessment Guidance for Superfund - Volume II, Environmental Evaluation Manual (US EPA, 1989)

- Ecological Risk Assessment, Hazard Evaluation Division, Standard Evaluation Procedure (US EPA, 1986)
- Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference (US EPA, 1989)
- Hazard Evaluation Division, Standard Evaluation Procedure, Ecological Risk Assessment (US EPA, 1986)
- User's Manual for Ecological Risk Assessment (US DOE, 1986)

Additional guidance was outlined in correspondence from the NJDEPE to L.E. Carpenter dated 18 March 1992 and specific guidance regarding strategies and scope were discussed with NJDEPE personnel on 18 May 1992.

## 2.2 Sample Locations

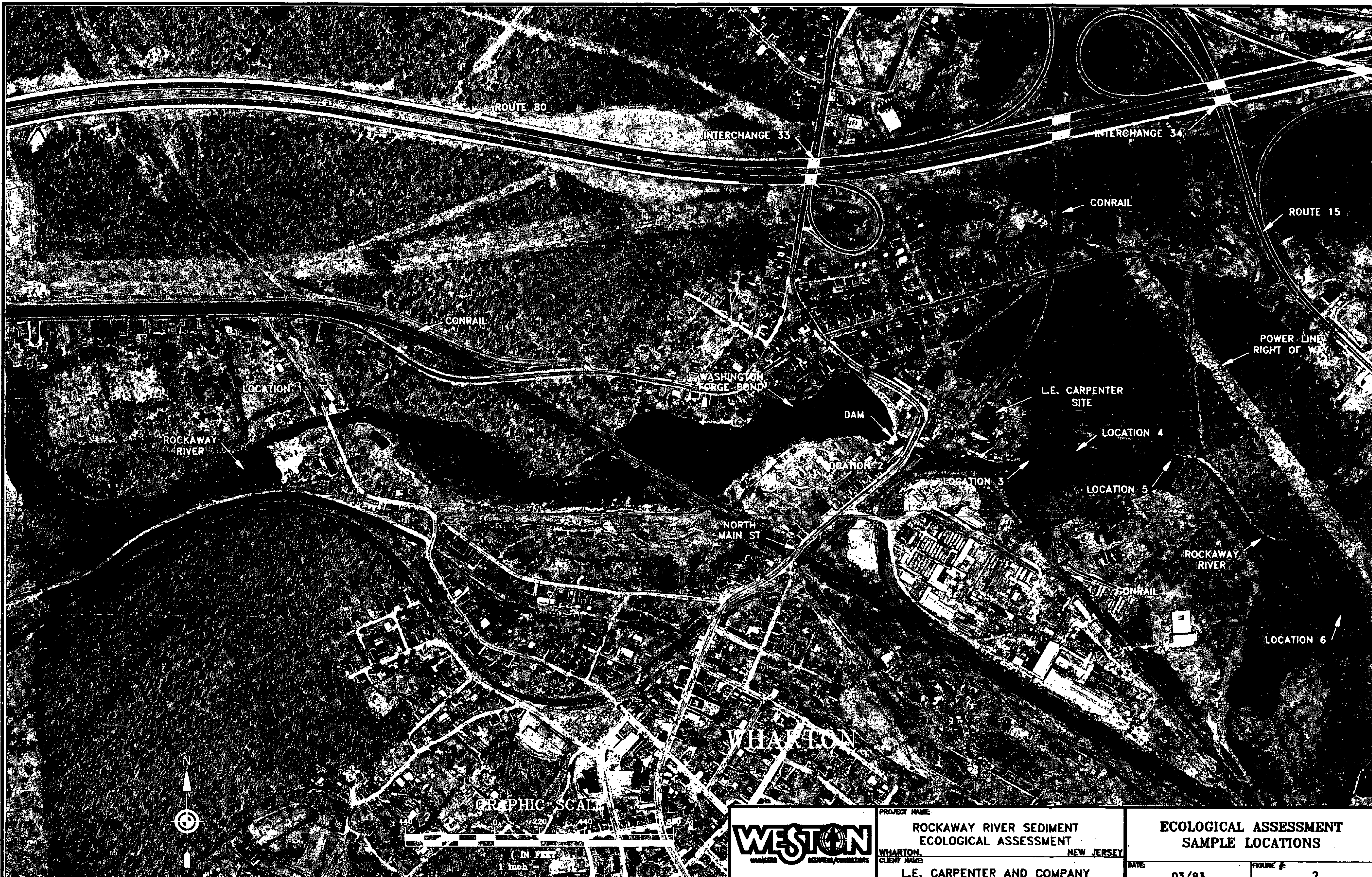
To the maximum extent possible, sampling locations were situated in areas of similar habitat. To facilitate the design of the investigation, the nature and extent of habitat at each potential sampling location was evaluated during a preliminary site reconnaissance. In particular, variables such as substrate composition, riparian vegetation, flow velocity, and watershed features were considered. Prior to the collection of samples on 17 September 1992, targeted sampling areas were discussed and specific locations identified in consultation with representatives of the NJDEPE.

Sample locations were assigned a number sequentially starting from the upstream extent of the study area (Figure 2). Two reference locations (1 and 2) were established in the Rockaway River based on the results of the site reconnaissance and previous sampling. Data collected from these locations were utilized to provide a basis for comparison of downstream locations, and to normalize the biological assessment to the best attainable situation. The use of multiple reference locations were intended to overcome potential problems related to habitat differences immediately downstream of the Washington Forge Pond spillway and contaminants present in the Rockaway River not attributable to the site (Smith et al., 1987). Two locations (3 and 4) adjacent to the site were utilized to identify and assess biological impairment potentially attributable to the site. Finally, two downstream locations (5 and 6) were used to document biological characteristics at increasing distances from the site.

## 2.3 Habitat Assessment

### 2.3.1 *In Situ* Water Quality Measurement

*In situ* water quality was determined at each sampling location using a Hydrolab Surveyor II.




| | | |
|---|---|---|
| WESTON MANAGERS DESIGNERS/CONSULTANTS | PROJECT NAME: ROCKAWAY RIVER SEDIMENT ECOLOGICAL ASSESSMENT<br>WHARTON, NEW JERSEY<br>CLIENT NAME: L.E. CARPENTER AND COMPANY | ECOLOGICAL ASSESSMENT SAMPLE LOCATIONS<br>DATE: 03/93 FIGURE #: 2 |

- Ecological Risk Assessment, Hazard Evaluation Division, Standard Evaluation Procedure (US EPA, 1986)
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## 2.3 Habitat Assessment

### 2.3.1 *In Situ* Water Quality Measurement

*In situ* water quality was determined at each sampling location using a Hydrolab Surveyor II.

The Hydrolab was calibrated prior to use as per the methodology detailed in the Hydrolab Corporation Owner's Manual (Hydrolab, 1985). A post-use calibration check was also performed to ensure that the data collected was not adversely compromised by sensor fouling or instrument drift. Parameters measured included temperature, dissolved oxygen, pH, conductivity, and oxidation-reduction potential.

### 2.3.2 Riparian and Instream Habitat Evaluation

Rockaway River aquatic and riparian habitat was evaluated in support of the macroinvertebrate survey (US EPA, 1989). A habitat assessment matrix based on stream classification guidelines for Wisconsin (Ball, 1982) and methods for evaluating stream riparian and biotic conditions (Platts et al., 1983) was used. Habitat parameters pertinent to the assessment of habitat quality were placed into primary, secondary, and tertiary categories. Primary categories are those that characterize the stream microscale habitat and have the greatest influence on the structure of the biological community. These include the bottom substrate and available cover, imbeddedness, and flow and depth. The secondary categories measure the macroscale habitat and include channel alteration, bottom scoring and deposition, and stream sinuosity. Tertiary categories evaluate riparian and bank stability and include bank stability, bank vegetation, and streamside cover.

All parameters were evaluated for each sampling location and assigned scores which were weighted to emphasize the most biologically significant parameters. The highest scores were awarded to locations with best quality habitat. The total score for each location was compared to the reference locations to provide a comparability measure. Each location was then classified on the basis of its similarity to the reference and its potential to support an expected biological community.

### 2.3.3 Vegetation Survey

A qualitative survey of the riparian vegetative community was conducted. Dominant taxa and broad community types were identified describing the general extent of the vegetation communities present.

## 2.4 <u>Biological Survey</u>

### 2.4.1 Scope

The biological survey of the Rockaway River focused on the riffle area benthic macroinvertebrate community, supplemented by a cursory examination of the coarse particulate organic matter macroinvertebrate community and the periphyton community. At each location, riffle areas were sampled and coarse particulate organic matter was collected. The riffle samples were quantitative in nature and were collected from five discrete areas at each sampling location.

Three samples were processed through the evaluation procedure. The data thus generated provided sufficient resolution to meet the study objectives, and the remaining samples were archived. The coarse particulate organic matter samples were qualitative in nature and one sample was composited from a number of areas at each location.

### 2.4.2 Riffle Area Macroinvertebrate Collection Method

Riffle areas were sampled primarily to evaluate the scraper and filterer functional feeding groups. Five discrete areas of comparable habitat were sampled at each location using a kick net. In order to permit comparisons, an equivalent level of effort was expended at each area and location. A long-handled, D-frame kick net, measuring approximately 45 centimeters wide and 20 centimeters tall, with 500 micron mesh was used to collect benthic macroinvertebrates from the Rockaway River. The upper portion of the net frame was positioned firmly on the substrate with the net expanded in a downstream direction by the current. A sampling area was established that measured approximately 45 centimeters in width and extended approximately 1 meter upstream of the net. The stream bottom within the sampling area was disturbed by overturning rocks and substrate to a depth of approximately 10 centimeters. Organisms thus dislodged were swept into the net by the current.

### 2.4.3 Coarse Particulate Organic Matter Macroinvertebrate Collection Method

Coarse particulate organic matter was collected primarily to evaluate the shredder functional group. Sampling involved collecting a sample composited from a variety of coarse particulate organic matter forms including plant parts, leaves, needles, twigs, and bark. Sample sources included the upstream face of boulders, rocks, and snags as well as shorezone areas where these materials typically collect. A variety of sources and forms were collected and composited from several areas at each location. Care was taken to avoid the collection of fully decomposed material as this tends to have the lowest shredder representation.

### 2.4.4 Periphyton and Macrophyte Collection Method

Periphyton was sampled at each location to provide information concerning the energetic basis of the stream ecosystem. Attached and crustose forms of nonvascular plant and animal material were qualitatively collected with forceps and pipets from hard substrate material and composited into a single sample. The distribution, abundance, and species composition of macrophytes were noted on field data sheets.

### 2.4.5 Field Processing of Samples

Kick net and coarse particulate organic matter collections were partially processed in the field. At all locations, the net contents or the coarse particulate organic matter were placed in a shallow white pan with a small volume of water. Organisms clinging to the net fabric were removed with forceps and added to the pan contents. To prevent damage to the organisms during transport and to ease the sorting task, large debris, stones, and other extraneous material was removed after ensuring that they were free of attached or clinging organisms. The remaining material was placed in 500 milliliter plastic containers and preserved with a four percent buffered formalin solution.

Periphyton samples were preserved with a four percent buffered formalin solution.

### 2.4.6 Laboratory Processing of Macroinvertebrate Samples

A 200 organism subsample was used as a time-saving sorting procedure for use with the kick net samples. This subsampling method is based on that used for Hilsenhoff's Biotic Index (Hilsenhoff, 1987) and is similar to that used by the New York Department of Environmental Conservation (Bode, 1988) and in Arkansas (Shackleford, 1988). The subsampling procedure consisted of evenly distributing the sample in a white bottomed, gridded pan. Grids were randomly selected, and all organisms within selected grids were removed until approximately 200 organisms were selected from the sample. This method of subsampling provided a representative estimate of the benthic fauna as well as a consistent unit of effort. The specific procedure used was as follows:

1. The sample was thoroughly rinsed in a No. 35 mesh (500-micron) screen to remove preservative. Large material (whole leaves, twigs, macrophyte mats or stones) retained in the sieve was rinsed and visually inspected; all organisms were retained.

2. The rinsed sample was placed in a white 30 x 46 centimeter polyethylene pan. The bottom of the pan was marked with a numbered grid pattern with each block in the grid measuring approximately 25 centimeters square. Samples too large to be sorted in a single pan were thoroughly mixed with some water and half of the homogenized sample was placed in each of two gridded pans. To ensure a representative subsample, each half of the sample was composed of the same kinds and quantity of debris and an equal number of grids were sorted from each pan.

3. Just enough water was added to allow complete dispersion of the sample within the pan; an excessive amount of water would have allowed the sample material to shift within the grid during sorting. The sample material was evenly distributed within the grid.

4. A random numbers table was used to select a number corresponding to a square within the gridded pan. All organisms were removed from within that square; this process continued until the total number sorted from the sample was within 15 percent of 200. Any organism which was lying over a line separating two squares was considered to be in the square containing its head. In those instances where it was not possible to determine the location of the head (worms for instance), the organism was considered

to be in the square containing the largest portion of its body. All squares selected were completely sorted, even after the 200 count was reached. An illuminated 5X magnifier was used to facilitate the sorting procedure.

All benthic macroinvertebrates in the subsample were identified to the lowest positively identified taxonomic level (generally genus or family), enumerated, and recorded on a laboratory bench sheet. Varying levels of taxonomic resolution were attained and separations ranged from order to genus, with most identifications made to the generic level. The size and life history stage, and state of taxonomic knowledge of the group determined the level of identification. The organisms were identified using appropriate taxonomic references (e.g.; Edmunds et al., 1976; Baumann et al., 1977; Wiggins, 1977; Pennack, 1978; Merritt and Cummins, 1984; Peckarsky et al., 1990; and Thorp and Covich, 1991). A representative subsample was identified by a second individual to meet the QA/QC requirements of the taxonomic analysis.

### 2.4.7 Laboratory Processing of Periphyton Samples

Wet mounts of periphyton samples were scanned using multiple magnifications ranging from 5X to 300X. Several random aliquots of the sample were enhanced with biological stains to facilitate the detection of specific groups of microorganisms. In particular, the relative abundance of blue-green, unicellular green and filamentous green algae, diatoms, fungi, and microarthropods were determined. This evaluation was qualitative in nature.

## 2.5 Data Analysis

The analysis of data included an assessment of numerical abundance, dominance and diversity, and functional feeding types. Using the raw benthic data, a numerical value was calculated for each of eight metrics (US EPA, 1989 and Brower and Zar, 1984). Calculated values were compared to values derived from the reference locations, and each metric was assigned a score according to the comparability (percent similarity) of calculated and reference values. Scores for the eight metrics were totaled and compared to the totaled metric score for the reference locations. The percent comparison between the total scores provided a final objective evaluation of biological condition.

Analysis of the trophic structure and functional integrity of the benthic macroinvertebrate community involved a descriptive summary of functional feeding groups. The classification of an organism into a group was based on morphological mechanisms of food acquisition, behavioral characteristics of an organism, and the physical/biochemical characteristics of the food item. Taxa were assigned a feeding group based on literature descriptions of mouth parts, gut contents, and ecology (Cummins, 1973; Cummins and Klug, 1979; and Merritt and Cummins, 1984). The functional feeding group classification was incorporated into the analysis for computation of metrics.

Six functional feeding groups were considered, including shredders, collectors (filterers and gatherers), scrapers, predators and omnivores (Table 1). Shredders consume coarse particulate organic matter composed primarily of decomposing vascular plant material. The microflora associated with this material is an important component of the total energy assimilated by this group. Collectors feed on fine particulate organic matter either by filtering this material from the water column (filterers), or by gathering it from deposits and sediment (gatherers). Scrapers possess specialized mouth parts that enable them to feed on periphyton. The periphyton community grows on submerged mineral and organic substrates and is composed of bacteria, protozoa, and algae. Predators are secondary consumers feeding on animal tissue. Omnivores are organisms not restricted to a particular food type, or the taxonomic group evaluated is comprised of a broad assembledge of organisms, not specifically adapted to a single mode of existence (i.e.; Chironomidae).

The raw benthic data collected in the 200 organism riffle subsample and the coarse particulate organic matter sample was summarized using the metrics listed below.

Riffle Sample
- Taxonomic Richness
- Modified Hilsenhoff Biotic Index (HBI)
- Ratio of Scraper and Filterer Functional Feeding Groups
- Ephemeroptera, Plecoptera, and Trichoptera (EPT) Taxa
- Ratio of EPT Taxa to Chironomidae
- Percent Contribution of Dominant Taxon
- Community Similarity Index (Community Loss Index)

Coarse Particulate Organic Matter Sample
- Ratio of Shredder Functional Feeding Group and Total Number of Individuals Collected

Each metric result was given a score based on percent comparability to the reference locations. Biological condition scores were assigned to each metric based on comparison to the reference locations. Scores were totaled and a biological condition category assigned based on percent comparability with the reference score. The habitat assessment, physical characterization, and water quality data were included in the evaluation process. Scores were totaled and a Biological Condition Category was assigned based on percent comparability with the reference scores.

## 2.6 Quality Assurance

The collection, preservation, and analysis of all samples followed the methods detailed above and in the guidance documents cited in Section 2.1.

Sampling equipment and field monitoring instruments were calibrated and used as per the manufacturers instructions.

**TABLE 1. FUNCTIONAL FEEDING GROUP ASSIGNMENTS OF MACROINVERTEBRATE TAXA COLLECTED FROM THE ROCKAWAY RIVER L.E. CARPENTER SITE WHARTON, NEW JERSEY SEPTEMBER 17-18, 1992**

| Taxa | Functional Feeding Group | | | | | |
|---|---|---|---|---|---|---|
| | Shredder | Collector-Filterer | Collector-Gatherer | Scraper | Predator | Omnivore |
| EPHEMEROPTERA | | | | | | |
| *Isonychia* | | X | | | | |
| *Baetis* | | | X | X | | |
| *Heptagenia* | | | X | X | | |
| *Stenacron* | | | X | X | | |
| *Stenonema* | | | X | X | | |
| *Ephemerella* | X | | X | X | | |
| ODONATA | | | | | | |
| *Ophiogomhus* | | | | | X | |
| *Progomphus* | | | | | X | |
| *Argia* | | | | | X | |
| PLECOPTERA | | | | | | |
| *Acroneuria* | | | | | X | |
| *Paragnentina* | | | | | X | |
| HEMIPTERA | | | | | | |
| *Species 1* | | | | | X | |
| MEGALOPTERA | | | | | | |
| *Sialis* | | | | | X | |
| *Corydalus* | | | | | X | |
| *Nigronia* | | | | | X | |
| TRICOPTERA | | | | | | |
| *Chimarra* | | X | | | | |
| *Lype* | | | X | | | |
| *Psychomyia* | | | X | | | |
| *Polycentropus* | | | | | X | |
| *Cheumatopsyche* | | X | | | | |
| *Hydropsyche* | | X | | | | |
| *Rhyacophila* | | | | | X | |
| *Pseudostenophylax* | X | | X | | | |
| LEPIDOPTERA | | | | | | |
| *Acentria* | X | | | | | |

## TABLE 1 (cont'd). FUNCTIONAL FEEDING GROUP ASSIGNMENTS OF MACROINVERTEBRATE TAXA COLLECTED FROM THE ROCKAWAY RIVER L.E. CARPENTER SITE WHARTON, NEW JERSEY SEPTEMBER 17-18, 1992

| Taxa | Functional Feeding Group | | | | | |
|---|---|---|---|---|---|---|
| | Shredder | Collector-Filterer | Collector-Gatherer | Scraper | Predator | Omnivore |
| COLEOPTERA | | | | | | |
| *Ectopria* | | | | X | | |
| *Psephenus* | | | | X | | |
| *Macronychus* | | | X | X | | |
| *Microcylleopus* | | | X | X | | |
| *Optioservus* | | | X | X | | |
| *Promoresia* | | | X | X | | |
| *Stenelmis* | | | X | X | | |
| *Helichus* | X | | | | | |
| DIPTERA | | | | | | |
| *Antocha* | | | X | | | |
| *Tipula* | X | | X | | | |
| Simulidae | | X | | | | |
| *Hemerodromi* | | | | | X | |
| Chironomidae | | | | | | X |
| MOLLUSCA | | | | | | |
| *Ferrissia* | | | | X | | |
| *Physa* | | | | X | | |
| *Goniobasis* | | | | X | | |
| *Sphaerium* | | X | X | | | |
| CRUSTACEA | | | | | | |
| *Orconectes* | | | | | | X |
| *Gammarus* | | | X | | | |
| *Hyalella* | | | X | | | |
| *Caecidotea* | | | X | | | |
| OLIGOCHAETA | | | | | | |
| *Species 1* | | | X | | | |
| TRICHADIDA | | | | | | |
| *Planariidae* | | | | | | X |

Source: Merritt and Cummings, 1984
Pennak, 1989
Thorp and Covich, 1991

All samples were collected, transferred, stored and analyzed using chain-of-custody procedures. Chain-of-custody records contained the site name, sample location, sample identification number, date collected, sample container, and preservative. Upon completion of a chain-of-custody and "received by" sections.

Habitat assessments and field collections were performed by the same team to ensure consistency and all field procedures and observations were documented.

Sample processing in the laboratory was performed by the same team to ensure consistency in sorting. Sample residue was used to determine sorting efficiency and precision and is currently archived by WESTON personnel. Subsampling was performed using a random numbers table. The taxonomic identification was confirmed by a second individual familiar with regional taxa.

# 3.0 RESULTS

## 3.1 Description of Study Area

The Rockaway River basin consists of a series of northeast-southwest trending valleys filled with thick sequences of glacial deposits. Headwaters originate in the Berkshire Valley and flow southwest parallel to the trend of the valley until reaching the main west-east trending Rockaway valley approximately one mile upstream of the site. In the vicinity of the site, the Rockaway River is a third order stream. The Washington Forge Pond is immediately upstream of the site and is a manmade waterbody created by the damming of the Rockaway River.

The Rockaway River immediately downstream of the Washington Forge Pond flows through a modified channel prior to passing under the North Main Street overpass and a railroad trestle. Between the trestle and the dam spillway, the Rockaway River flows through a channelized corridor. In this area, the river is approximately 30 feet wide and ranges to one foot in depth. The canopy cover is less than 50 percent and the riparian vegetative community has been reduced in extent and species composition by adjacent structure and development. The river substrate is relatively homogenous and consists of sand to cobble sized particles. The Washington Forge Pond dam releases epilimnetic water to the Rockaway River.

Downstream of the trestle and adjacent to the southwest corner of the site, the Rockaway River broadens to include the historic channel on the south and a basin or flume, presumably designed to receive water from the steel penstock, on the north. This flume portion of the channel flows sluggishly for approximately 125 feet along a concrete wall that forms the southern border of the site. With the exception of a small area near the steel penstock, the flume is isolated from the main channel of the Rockaway River by a narrow island that extends for approximately 75 downstream from the outfall of the steel penstock. The main channel of the Rockaway River is approximately 25 feet wide and ranges to two feet in depth. The substrate is highly variable and consists of sand to bolder sized particles. Although restricted somewhat by the steep valley wall to the south and the site to the north, the canopy cover is approximately 80 percent and is variable in species composition.

Adjacent to the southeast corner of the site, the Rockaway River flows in an easterly direction through a series of braided channels. This network expands in complexity as the floodplain increasingly broadens to form a riparian wetland. With the exception of size, the rivulets forming the braided network are similar to the upstream channel. The channels typically range from five to ten feet in width and to one foot in depth. The canopy cover is almost 100 percent in this area. Due to the relatively consistent gradient, the water velocity in this area remains similar to that in the upstream channel. The substrate consists of fine sand to cobble sized particles. In a number of locations, manmade cobble barriers impede the flow and small pools are formed in the channel immediately upstream.

Approximately 400 feet downstream of the site, the wetland rivulets coalesce into a single channel. A large manmade cobble and boulder barricade is present approximately 30 feet downstream of this confluence and forms a pool ranging to five feet in depth. Further downstream, the Rockaway River flows through a well defined channel with a substrate consisting of sand to cobble sized particles. In some areas, extensive development has encroached upon the riparian vegetative community and canopy cover is less than 25 percent.

As suggested by the discussion above, the Rockaway River in the vicinity of the L.E. Carpenter Site is a highly variable waterbody draining a landscape including relatively undisturbed forested flats, low to high density residential areas, commercial and industrial sites, and a manmade pond. Further, morphometry ranges from a highly defined and restricted channel to unrestricted braided flow. Consequently, in spite of careful habitat evaluation, it was not possible to identify sampling locations that embody identical habitat attributes. Further, it was not feasible to utilize a regional reference due to contaminants in the Rockaway River not attributable to the L.E. Carpenter Site. Therefore, as discussed previously, multiple reference locations were selected that collectively possess habitat characteristics similar to those observed at downstream location.

## 3.2 Habitat Assessment

### 3.2.1 Water Quality

*In situ* water quality of the Rockaway River was measured at each sampling location from 0918 to 1339 on 18 September 1992 (Table 2). Temperature increased from 18.9 degrees Centigrade (°C) to 21.8° C throughout the monitoring period, dissolved oxygen concentrations decreased from 8.5 milligrams per liter (mg/L) to 7.5 mg/L. Values observed for pH, conductivity, and oxidation-reduction potential were relatively consistent throughout the monitoring period and across all locations.

### 3.2.2 Physical Characteristics of Sampling Locations

There was a wide range in physical habitat variables observed throughout the study area (Table 3). Differences between locations centered primarily on the degree of disturbance.

Location 6 received the highest overall score of 121 (Table 3). With the exception of streamside cover, which received a score of good, excellent conditions were observed for all other habitat parameters. Location 6 was situated approximately 600 meters downstream of the site in a relatively undisturbed forested wetland. With the exception of a utility right-of-way approximately 25 meters to the west, little evidence of local watershed erosion or non-point source pollution was evident. The Rockaway River in the vicinity of the riffle area sampled ranged from 5 to 15 centimeters in depth and was approximately 5 meters in width. The uniform sequence of riffle, runs, and pools, as well as the presence of cobbler and boulder

## TABLE 2. IN SITU WATER QUALITY OF THE ROCKAWAY RIVER
## L.E. CARPENTER SITE
## WHARTON, NEW JERSEY
## SEPTEMBER 18, 1992

| Parameter | Sample Location | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Temperature (°C) | 18.9 | 19.8 | 20.8 | 21.0 | 21.7 | 21.8 |
| Dissolved Oxygen (mg/l) | 8.5 | 8.3 | 7.9 | 8.0 | 7.5 | 7.8 |
| pH (units) | 8.1 | 8.1 | 8.2 | 8.2 | 8.3 | 8.3 |
| Conductivity (uS/cm) | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Oxidation-reduction potential (V) | 88 | 84 | 86 | 88 | 86 | 87 |
| Time | 0918 | 0941 | 1040 | 1127 | 1229 | 1339 |

## TABLE 3. HABITAT ASSESSMENT SUMMARY OF THE ROCKAWAY RIVER
## L.E. CARPENTER SITE
## WHARTON, NEW JERSEY
## SEPTEMBER 18-19, 1992

| Condition/Parameter | Sample Location | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| **Primary-Substrate and Instream Cover** | | | | | | |
| Bottom substrate/available cover | 18 | 14 | 12 | 12 | 14 | 18 |
| Embeddedness | 18 | 16 | 6 | 10 | 12 | 18 |
| Flow velocity | 18 | 8 | 14 | 14 | 14 | 17 |
| **Secondary-Channel Morphology** | | | | | | |
| Channel alteration | 12 | 8 | 6 | 8 | 8 | 12 |
| Bottom scouring/deposition | 12 | 4 | 5 | 5 | 6 | 14 |
| Pool/riffle, run/bend ratio | 10 | 6 | 10 | 10 | 8 | 14 |
| **Tertiary-Riparian and Bank Structure** | | | | | | |
| Bank stability | 8 | 4 | 8 | 9 | 9 | 10 |
| Bank vegetative stability | 6 | 3 | 8 | 9 | 9 | 10 |
| Streamside cover | 5 | 6 | 9 | 9 | 9 | 8 |
| Total score | 107 | 69 | 78 | 86 | 89 | 121 |
| **Comparability** | | | | | | |
| To location 1 | --- | 64 | 73 | 80 | 83 | 113 |
| To location 2 | 155 | --- | 113 | 125 | 129 | 175 |

## HABITAT ASSESSMENT CONDITION RATINGS

| Condition/Parameter | Condition Rating | | | |
|---|---|---|---|---|
| | Excellent | Good | Fair | Poor |
| Primary-Substrate and Instream Cover | 16-20 | 11-15 | 6-10 | 0-5 |
| Secondary-Channel Morphology | 12-15 | 8-11 | 4-7 | 0-3 |
| Tertiary-Riparian and Bank Structure | 9-10 | 6-8 | 3-5 | 0-2 |

| Assessment Category | Percent Comparability |
|---|---|
| Comparable to references | ≥ 90 |
| Supporting | 75-88 |
| Partially Supporting | 60-73 |
| Non-supporting | ≤ 58 |

barricades, suggests that the Rockaway River has been altered to enhance trout habitat and production. Further, the stream banks in the vicinity of this location have been stabilized with cobble and boulders removed from the channel; this activity has also enhanced pool areas. This has created the appearance of a channelized stream, and most likely limits or deters hydrologic communication with the riparian area. The canopy cover was 100 percent and included red maple, black gum, elm, and white oak. The sediment was normal in color and odor and was composed primarily of cobble and gravel sized particles. Very little coarse particulate organic matter was present in the stream.

Location 1 received the second highest overall score of 107 (Table 3). Excellent scores were received for all primary parameters and channel alteration and bottom scoring and deposition. Good scores were received for pool/riffle, run/bend ratio, bank stability, and bank vegetative stability. Streamside cover received a rating of fair. Location 1 was the auxiliary upstream reference location and was utilized to supplement location 2 (situated immediately upstream of the site) and compensate for the presence of Washington Forge Pond. Location 1 was situated approximately 300 meters upstream of the western extent of Washington Forge Pond and approximately 1400 meters upstream of the site. The predominant land use in the immediate vicinity of sampling location 1 is low density residential housing, with forested areas further upstream. Residential areas are susceptible to moderate erosion potential and represents a source of non-point source pollution including runoff from fertilizer and pesticide treated turf. Evidence of this was observed in adjacent areas where patches of unvegetated soil and mowed turf were observed immediately adjacent to the stream bank. The Rockaway River in the vicinity of the sampled riffle area ranged from 10 to 25 centimeters in depth and was approximately 12 meters in width. The substrate was composed primarily of cobble sized particles. The uniform appearance of the riffle-pool interface suggests that the Rockaway River has been altered in this area. This may be due to the presence of a road crossing immediately downstream of the riffle area or have been altered in this fashion to enhance trout production. The sediment was normal in appearance and odor. The canopy cover was less than 5 percent and the riparian area was vegetated with a mowed turf-ornamental association. Although very little coarse particulate organic matter was present in the stream, a dense mat of moss was observed in the northern portion of the riffle area.

Locations 4 and 5 were very similar in appearance and received overall scores of 86 and 89, respectively (Table 3). For both locations, good to fair ratings were received for primary and secondary parameters, and excellent ratings were received for all tertiary parameters. Locations 4 and 5 were situated adjacent to the southern site border and approximately 200 and 250 meters downstream of the eastern corner of the site, respectively. At these locations, the Rockaway River flows through a relatively broad flood plain bounded by the site to the north and the conrail railroad bed to the south. Although the river consists of multiple channels connected by numerous, small irregular, braided channels, the main channel was situated along the southern edge of the flood plain. To ensure the detection of potential site related impacts, all sampling activities were restricted to the northern braids of the Rockaway River complex (i.e.; those immediately adjacent to the site). The river network forms the central core of a riparian wetland hydrosystem that extends in an easterly direction from the eastern corner of the site to beyond location 6. The predominant landuse outside of the floodplain is commercial and industrial. Although the immediate riparian area was forested, local watershed erosion potential was judged to be moderate. Numerous non-point sources of pollution were observed including runoff from road crossings, a utility right-of way, and commercial facilities. The Rockaway River in the vicinity of locations 4 and 5 ranged from 15 to 25 centimeters in depth and the channel area was approximately 40 meters in width; the channel braids sampled ranged from 3 to 4 meters in width. The substrate was composed primarily of cobble sized particles with a substantial proportions of sand. Very little coarse particulate organic matter was present in the stream. Although the substrate was normal in odor, many substrate particles were irregular in shape with sharp angular edges. The canopy cover was approximately 80 percent and included red maple, elm, and white oak.

Location 3 received an overall score of 78 (Table 3). Good to fair ratings were received for all habitat parameters with the exception of streamside cover which received a score of excellent. Location 3 was situated adjacent to the southeastern corner of the site and downstream of the steel penstock and flume. At this location, the Rockaway River consists of two parallel channels and a series of small irregular connecting channels. As above, all sampling activities were restricted to the northern channels braids of the Rockaway River complex to ensure the detection of potential site related impacts. The floodplain and river channels have been compressed between the site and associated concrete retaining wall to the north and the Conrail railroad bed to the south. The predominant landuse outside of the floodplain was industrial. Although the immediate riparian area was forested, local watershed erosion potential was judged to be moderate. Numerous non-point sources of pollution were observed including runoff from road crossings, rail beds and industrial facilities. The riffle area sampled at location 3 ranged from 20 to 30 centimeters in depth and the channel area was approximately 30 meters in width; the channel braids sampled ranged from 1 to 3 meters in width. The substrate was composed primarily of cobble sized particles with substantial proportions of gravel and sand. Very little coarse particulate organic matter was present in the stream. Although the substrate was normal in odor, many substrate particles were irregular in shape with sharp angular edges. The canopy cover was approximately 85 percent and included red maple, elm, and white oak.

Location 2 received the lowest overall score of 69 (Table 3). With the exception of embeddedness, which received a score of excellent and bank vegetative stability, which received a score of poor, good to fair conditions were observed for all other habitat parameters. Location 2 was the site specific reference location; however, as mentioned above, the presence of Washington Forge Pond necessitated the inclusion of a second reference location further upstream. The predominant land use in the immediate vicinity of the sampling location is commercial/industrial, with low density residential housing situated along the shore of Washington Forge Pond, a 540 hectare manmade waterbody. The spillway releases epilimnetic water from the pond and is situated approximately 10 meters upstream of the sampled riffle area.

Water flowing across the spillway drops approximately 3 meters onto a concrete pad prior to entering the river channel. Due to the high energy of the spillway, the channel immediately downstream of the pad has been eroded to form an extensive pool approximately 1.25 meters in depth. Numerous non-point sources of pollution were observed including runoff from road crossings and adjacent industrial facilities. The immediate riparian area has been encroached upon be commercial establishments and fairly extensive areas of bare soil were present on steeply sloping streambanks, resulting in high erosion potential. The Rockaway River in the vicinity of the sampled riffle area ranged from 5 to 15 centimeters in depth and was approximately 10 meters in width. The substrate was normal in color and odor, and was composed primarily of cobble sized particles. The canopy cover was less than 10 percent and little riparian vegetation other than disturbance adapted species remain. Although very little coarse particulate organic matter was present in the stream, numerous *Vallisneria* tufts were observed in the more sheltered areas of the riffle.

## 3.3 Macroinvertebrate Survey

### 3.3.1 Riffle Community

#### 3.3.1.1 Community Structure

A total of 46 taxonomic groups were collected from the Rockaway River (Table 4). Of these, 1 was an Oligochaete, 1 was a Tubellarian, 3 were Crustaceans, 4 were Molluscs, and 37 were Insects.

The dominant group, in terms of taxonomic diversity, were the Tricopterans and Coleopterans. These groups were represented by 8 taxa each. However, two Tricopteran taxa, including *Lype* and *Psychomyia* were collected from only one location (location 5) in the Rockaway River. Three taxa were collected from three locations, and three taxa were collected from all locations. In contrast, the Coleopteran taxa were more cosmopolitan in distribution. Three Coleopteran taxa were collected from at least two locations, two were collected from 4 locations, one was collected from five locations, and two were collected from all sampling locations. A total of 6 Ephemeropteran taxa were collected from the Rockaway River. Of these, only *Ephemerella* was collected from a single location; one taxa was collected from two locations, one was collected from three locations and three were collected from all sampling locations. A total of 5 Dipteran taxa were collected; two were collected from two locations, 1 from 4 locations, 1 from 5 locations and 1 from 6 locations. The remaining groups were represented from 4 or fewer taxa.

In general, *Isonychia* was the dominant taxa collected from the Rockaway River. It was present at every location and was the most numerically abundant organism at locations 1, 2, 3, and 6, where it represented approximately 25, 36, 40, and 27 percent of the individuals collected, respectively. Other taxa, including *Baetis*, *Stenonema*, and to a lessor extent, *Optioservis* were present at most locations in consistently significant proportions. A number of organisms were

## TABLE 4. BENTHIC MACROINVERTEBRATES COLLECTED FROM RIFFLE AREAS OF THE ROCKAWAY RIVER
## L.E. CARPENTER SITE
## WHARTON, NEW JERSEY
## SEPTEMBER 18-19, 1992

| Taxa | Sample Location | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | | | 2 | | | | 3 | | | | 4 | | | | 5 | | | | 6 | | | |
| | A | B | C | T | A | B | C | T | A | B | C | T | A | B | C | T | A | B | C | T | A | B | C | T |
| **EPHEMEROPTERA** | | | | | | | | | | | | | | | | | | | | | | | | |
| Isonychia | 38 | 37 | 70 | 145 | 82 | 82 | 67 | 231 | 67 | 77 | 104 | 248 | 9 | 36 | 33 | 78 | 28 | 10 | 25 | 63 | 52 | 92 | 13 | 157 |
| Baetis | 21 | 31 | 33 | 85 | 21 | 13 | 10 | 44 | 4 | 8 | 9 | 21 | 4 | 16 | 1 | 21 | 9 | 12 | 29 | 50 | | 1 | 1 | 2 |
| Heptagenia | 2 | 3 | | 5 | | | | | | | | | | | | | | 2 | 7 | 9 | | | | |
| Stenacron | | 3 | | 3 | | | | | | | | | 3 | | | 3 | | | 8 | 8 | | | | |
| Stenonema | 48 | 52 | 19 | 119 | 11 | 7 | 9 | 27 | 8 | 4 | 5 | 17 | 16 | | 13 | 29 | 14 | 21 | 72 | 107 | 11 | 42 | 20 | 73 |
| Ephemerella | | | | | | | | | 1 | | | 1 | | | | | | | | | | | | |
| **ODONATA** | | | | | | | | | | | | | | | | | | | | | | | | |
| Ophiogomphus | 3 | | 2 | 5 | | | | | | | | | | | | | | | | | | | | |
| Progomphus | | | | | | | | | 2 | | | 2 | 2 | 1 | 9 | 12 | | | | | | | 1 | 1 |
| Argia | | 9 | | 9 | | | 2 | 2 | 3 | 2 | 5 | 10 | 3 | 2 | 2 | 7 | | 2 | 4 | 6 | | 1 | | 1 |
| **PLECOPTERA** | | | | | | | | | | | | | | | | | | | | | | | | |
| Aeroneuria | 2 | 1 | | 3 | | | | | | | | | | | | | | | | | 1 | 2 | 3 | 6 |
| Paragretina | 6 | 1 | 7 | 14 | | 1 | | 1 | 1 | 2 | | 3 | 1 | 7 | 1 | 9 | 4 | 12 | 2 | 18 | 5 | 2 | 1 | 8 |
| **HEMIPTERA** | | | | | | | | | | | | | | | | | | | | | | | | |
| Species 1 | 1 | | | 1 | | | | | | | 1 | 1 | 1 | | | 1 | 1 | | | 1 | | | | |
| **MEGALOPTERA** | | | | | | | | | | | | | | | | | | | | | | | | |
| Sialis | 4 | 2 | 1 | 7 | | | | | 1 | | 1 | 2 | 5 | 1 | 3 | 9 | 4 | 1 | | 5 | | 1 | 5 | 6 |
| Corydalus | | | 1 | 1 | 1 | 3 | 2 | 6 | | 1 | 2 | 3 | | 1 | 1 | 2 | | | | | 1 | | | 1 |
| Nigronia | 1 | 1 | 5 | 7 | | | | | 2 | | 2 | 4 | 5 | 1 | 8 | 14 | 3 | 2 | | 5 | 3 | 8 | 4 | 15 |
| **TRICOPTERA** | | | | | | | | | | | | | | | | | | | | | | | | |
| Chimarra[1] | 5 | | 2 | 7 | 4 | 6 | 9 | 19 | 4 | 12 | 7 | 23 | | 4 | | 4 | 37 | 5 | | 42 | 33 | 31 | 9 | 73 |
| Lype | | | | | | | | | | | | | | | | | | 7 | 1 | 8 | | | | |
| Psychomyia | | | | | | | | | | | | | | | | | | 2 | | 2 | | | | |
| Polycentropus | 1 | | | 1 | | | | | | | | | 1 | | | 1 | | 1 | | 1 | | | | |
| Chematopsyche[1] | 2 | 1 | 7 | 10 | 48 | 50 | 72 | 170 | 13 | 33 | 20 | 66 | 2 | 7 | 9 | 18 | 8 | 5 | 11 | 24 | 8 | 21 | 16 | 45 |
| Hydropsyche[1] | 9 | 5 | 4 | 18 | 19 | 17 | 12 | 48 | 12 | 36 | 37 | 85 | 2 | 2 | 17 | 21 | 10 | 6 | 13 | 29 | 20 | 33 | 35 | 88 |
| Rhyacophila | | | 1 | 1 | | | | | | | 1 | 1 | | | | | | | | | | 1 | | 1 |
| Pseudostenophylax[1] | 5 | | | 5 | | | | | | | | | 1 | | 2 | 3 | 1 | | 4 | 5 | | | | |
| **LEPIDOPTERA** | | | | | | | | | | | | | | | | | | | | | | | | |
| Acentria | | | | | | 1 | | 1 | | | | | | | | | | | | | | | | |

## TABLE 4 (cont'd).
## BENTHIC MACROINVERTEBRATES COLLECTED FROM RIFFLE AREAS OF THE ROCKAWAY RIVER
## L.E. CARPENTER SITE
## WHARTON, NEW JERSEY
## SEPTEMBER 18-19, 1992

| Taxa | Sample Location | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | | | 2 | | | | 3 | | | | 4 | | | | 5 | | | | 6 | | | |
| | A | B | C | T | A | B | C | T | A | B | C | T | A | B | C | T | A | B | C | T | A | B | C | T |
| **COLEOPTERA** | | | | | | | | | | | | | | | | | | | | | | | | |
| Ectopria | | | | | | | | | 1 | 1 | | 2 | | | | | 1 | | | 1 | | | | |
| Psephenus | 33 | 16 | 13 | 62 | | | | | | 1 | | 1 | 4 | | 12 | 16 | 2 | 3 | 6 | 11 | | 7 | 9 | 16 |
| Macronychus | 1 | 1 | | 2 | | | | | | | | | | | | | | 1 | 2 | 3 | | | | |
| Microcylleopus | 2 | 3 | 4 | 9 | 1 | 1 | 1 | 3 | 1 | | | 1 | | | | | 1 | | | 1 | | | | |
| Optioservus | 1 | 10 | 1 | 12 | | | 1 | 1 | 2 | 5 | 24 | 31 | 3 | | 1 | 4 | 2 | 10 | 3 | 15 | 1 | 19 | 13 | 33 |
| Promoresia | | | 1 | 1 | | | | | | 1 | 3 | 4 | | | | | 4 | | 16 | 20 | 2 | 7 | 6 | 15 |
| Stenelmis | 1 | 10 | 3 | 14 | | | 4 | 4 | 3 | 3 | 8 | 14 | 2 | 4 | 4 | 10 | 1 | 3 | | 4 | | 1 | | 1 |
| Helichus | | | | | | | | | | | | | | | | | | 1 | 1 | 2 | | | 1 | 1 |
| **DIPTERA** | | | | | | | | | | | | | | | | | | | | | | | | |
| Antocha | | 1 | | 1 | | | | | | 2 | 1 | 3 | | | | | | 4 | | 4 | 1 | | | 1 |
| Tipula | | | | | | | 1 | 1 | | | | | | | | | | | 1 | 1 | | | | |
| Simulidae | | 1 | 3 | 4 | 6 | 3 | 6 | 15 | | 13 | 4 | 18 | | 4 | | 4 | 1 | 2 | 1 | 4 | 14 | | 1 | 15 |
| Hemerodromia | | 1 | | 1 | | | | | 1 | | | | | | | | 1 | | 1 | 2 | | | | |
| Chironomidae | | | | | 2 | 4 | 6 | 12 | | 8 | 5 | 13 | | 1 | 1 | 2 | 3 | 11 | 16 | 30 | 8 | 5 | 3 | 16 |
| **MOLLUSCA** | | | | | | | | | | | | | | | | | | | | | | | | |
| Ferrissia | | 1 | 1 | 2 | | | | | | 1 | | 1 | | | | | | | | | | | | |
| Physa | | | | | | 1 | | 1 | | | | | | | | | | | | | | | | |
| Goniobasis | | | | | | | 1 | 1 | | | | | | | | | | | | | | | | |
| Sphaerium | | | | | 4 | 8 | 21 | 33 | 7 | 9 | 10 | 26 | 10 | 9 | 21 | 40 | 7 | | 7 | 14 | | 6 | 2 | 8 |
| **CRUSTACEA** | | | | | | | | | | | | | | | | | | | | | | | | |
| Orconectes | 1 | 1 | | 2 | | | | | 1 | | | 1 | 1 | | 2 | 3 | 1 | | | 1 | | | | |
| Gammarus | 9 | 7 | | 16 | 3 | 3 | 7 | 13 | 5 | 8 | | 13 | 60 | 32 | 67 | 159 | 21 | 23 | 1 | 45 | | 1 | | 1 |
| Caecidotea | 1 | | | 1 | | | | | | | | | | | | | | 1 | | 1 | | | | |
| **OLIGOCHAETA** | | | | | | | | | | | | | | | | | | | | | | | | |
| Species 1 | 2 | 1 | 1 | 5 | | | | | 1 | 1 | | 2 | 1 | 3 | 2 | 6 | 3 | 4 | 1 | 8 | 1 | 3 | 4 | 8 |
| **TRICLADIOA** | | | | | | | | | | | | | | | | | | | | | | | | |
| Planariidae | 2 | | | 2 | 2 | 3 | 1 | 6 | | | | | | | | | | | | | | | | |

A, B, & C = Sample replicates
T = Total
1 = Larvae and pupa collected

consistently observed at all sampling locations, but in low numbers. For example, the Odonate *Argia*, the Plecopteran *Paragnetina*, the Coleopteran *Stenelmis*, and the Dipteran Simulidae were collected in low numbers at all locations.

In contrast, some taxa followed variable distribution patterns. At location 4, *Gammarus* was the most numerically abundant organism and represented 33 percent of the organisms collected. Although collected at all other sampling locations, it was typically a minor component of the community. The distribution of some other taxa followed irregular distribution patterns as well. For example, the Tricopterans *Cheumatopsyche* and *Hydropsyche*, and the bivalve *Sphaerium* were present at most sampling locations, but numerically significant only at locations 2, 3 and 4. Finally, the Coleopterian *Psephenus* represented over 10 percent of the community at location one, but was infrequently collected or collected in low numbers throughout the rest of the study area.

Most taxa were collected infrequently, and in low numbers. In addition to *Ephemerella* mentioned above, other organisms, including *Ophiogomphus*, *Lype*, *Psychomyia*, *Acentria*, *Physa*, and *Goniobasis* were collected at only one location. The most common distribution pattern observed was one where a taxa was collected in relatively low numbers, at few to several locations. Examples include *Heptagenia*, *Stenarcon*, *Progomphus*, *Aeroneuria*, *Polycentropus*, *Rhyacophila*, *Pseudostenophylax*, *Ectopria*, *Macronychus*, *Microcylloepus*, *Antocha*, *Ferrissia* and *Orconectes*.

3.3.1.2 Community Function

Six functional feeding groups were collected from Rockaway River (Table 5). Filterers were the dominant group and were collected from all locations. Representation ranged from 30 percent at locations 4 and 5 to 77 percent at location 2. Gatherers were the next most abundant group and ranged in representation from 11 percent at location 2 to 46 percent at 4. Scrapers were present in substantial numbers only at locations 1 and 5 where they represented 32 and 18 percent of the community, respectively; scrapers represented less than 9 percent of the community at the remaining locations. Shredders, predators, and omnivores were not dominant components of the benthic community at any location sampled and collectively represented less than 17 percent of the individuals at any one location.

Several distinct trends were observed in the relative distribution of functional feeding groups among locations. At location 1, filterers represented 31 percent of the community, but increased to 77 and 73 percent at locations 2 and 3. Their representation decreased to 30 percent at locations 3 and 4, then increased to 64 at location 6. A similar, but diametrically opposite trend was observed in the distribution of gatherers. Relatively high representation was observed at locations 1, 4, and 5, with lower representation at locations 2, 3 and 6. Scrapers were a dominant group only at location 1 where they represented 32 percent of the macroinvertebrate community; representation ranged from 6 to 18 percent at all other locations.

**TABLE 5. PERCENT COMPOSITION BY FUNCTIONAL FEEDING GROUPS[1] OF BENTHIC MACROINVERTEBRATES COLLECTED FROM RIFFLE AREAS OF THE ROCKAWAY RIVER L.E. CARPENTER SITE WHARTON, NEW JERSEY SEPTEMBER 18-19, 1992**

Values reported as percent of total collection

| Group | Sample Location | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Shredders | 1 | 1 | 1 | 2 | 5 | 4 |
| Collector-filterers | 31 | 77 | 73 | 30 | 30 | 64 |
| Collector-gatherers | 23 | 11 | 12 | 46 | 34 | 13 |
| Scrapers | 32 | 6 | 8 | 9 | 18 | 9 |
| Predators | 9 | 2 | 4 | 12 | 7 | 7 |
| Omnivores | 4 | 3 | 2 | 1 | 6 | 3 |

(1) Modified from Merritt and Cummins, 1984.

### 3.3.1.3 Metrics

The number of taxa reflects the health of the community through a measurement of the variety of taxa (total number of genera and/or species) present. Taxa richness generally increases with increasing water quality, habitat diversity, and/or habitat suitability. The number of taxa collected at a single location ranged from 21 at location 2 to 35 at location 5 (Table 6). The lowest taxonomic diversity was observed at location 2, immediately downstream of Washington Forge Pond and the highest taxonomic diversity was observed at locations 1 and 5. A total of 29, 25, and 25 taxa were collected from locations 3, 4, and 6, respectively. Ranking of locations from lowest to highest water quality as suggested by taxa richness is as follows: 2<4=6<3<1<5.

The Hilsenhoff Biotic Index (HBI) summarizes the overall pollution tolerance of the benthic arthropod community with a single value (Hilsenhoff, 1987). Tolerance values range from 0 to 10, and increase as water quality decreases (Table 6). The Modified HBI was developed as a means of detecting organic pollution in communities inhabiting rock or gravel riffles, and has been modified to include non-arthropod species as well, on the basis of the biotic index used by the State of New York (Bode, 1988). Modified HBI index values calculated for the Rockaway River ranged from 5.43 (fair water quality) at location 3 to 4.54 (good water quality) at location 5. Ranking of locations from lowest to highest water quality as suggested by HBI values is as follows: 3<2<4=6<1<5.

The scraper/filterer functional feeding group ratio reflects the riffle community foodbase and provides insight into the nature of potential disturbance factors. The proportion of the two feeding groups is important because predominance of a particular feeding type may indicate an unbalanced community responding to an overabundance of a particular food source. The predominant feeding strategy reflects the type of impact detected. The scraper/filterer ratio ranged from 0.08 at location 2 to 1.02 at location 1 (Table 6). Values for other locations were typically less than 0.60. Scraper/filterer ratios less than one suggest that the predominant source of energy is suspended organic matter; this is likely the case at locations downstream of Washington Forge Pond. At location 1 the ratio is 1.02, which suggests that there is an equal number of organisms feeding on periphyton as on suspended organic matter. In contrast, at location 2 the ratio is 0.08, which suggests that there is a significantly higher proportion of filter feeding organisms than scrapers. The relative dominance of filter feeding organisms relative to scrapers was also observed at locations 3, 4, 5 and 6.

The Ephemeroptera, Plecoptera, Trichoptera (EPT) index is the total number of distinct taxa within the orders Ephemeroptera, Plecoptera, and Trichoptera. This value summarizes taxa richness within the insect orders that are generally considered to be pollution sensitive and this value generally increases with increasing water quality. The EPT Taxa Index ranged from 7 at location 2 to 13 at locations 1 and 5 (Table 6). Ranking of locations from lowest to highest water quality as suggested by EPT values is as follows: 2<3<4=6<5=1.

**TABLE 6. METRIC VALUES FOR THE MACROINVERTEBRATE COMMUNITY COLLECTED FROM RIFFLE AREAS OF THE ROCKAWAY RIVER L.E. CARPENTER SITE WHARTON, NEW JERSEY SEPTEMBER 17-18, 1992**

| Metric | Sample Location | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Taxonomic Richness | 34 | 21 | 29 | 25 | 35 | 25 |
| HBI (modified)[(1)] | 4.59 | 5.28 | 5.43 | 4.67 | 4.54 | 4.67 |
| Scraper/Filterer Ratio | 1.02 | 0.08 | 0.10 | 0.30 | 0.59 | 0.14 |
| EPT Taxa | 13 | 7 | 9 | 10 | 13 | 10 |
| EPT/Chironomidae Ratio | NC | 45 | 36 | 94 | 12 | 28 |
| % Contribution (Dom. Taxa) | 25 | 36 | 40 | 33 | 19 | 27 |
| Community Loss Index | | | | | | |
| 1 vs. | ---- | 0.81 | 0.25 | 0.45 | 0.20 | 0.41 |
| 2 vs. | 0.17 | ---- | 0.17 | 0.28 | 0.17 | 0.23 |

(1) HBI Index Values: 0.00-3.75, excellent; 3.76-4.25, very good; 4.25-5.00, good; 5.01-5.75, fair; 5.76-6.50, fairly poor; 6.51-7.25, poor; 7.25-10.0, very poor

The EPT taxa and Chironomidae abundance ratio uses relative abundance of these indicator groups as a measure of community balance. Good biotic condition is reflected in communities having a fairly even distribution among all four major groups and with substantial representation in the sensitive groups such as Ephemeroptera, Plecoptera, and Trichoptera. Skewed populations having a disproportionate number of the generally tolerant Chironomidae relative to the more sensitive EPT insect groups may indicate environmental stress (Ferrington, 1987). The EPT/Chironomidae Ratio ranged from 12 at location 5 to 94 at location 4 (Table 6). Because Chironomids were not collected from location 1, the EPT/Chironomidae Ratio could not be calculated. Ranking of locations from lowest to highest water quality as suggested by the EPT/Chironomidae Ratio values is as follows: 5<6<3<2<4.

The percent contribution of the numerically dominant taxon to the total number of organisms is an indication of community balance at the lowest positive taxonomic level. (The lowest positive taxonomic level is genus.) A community dominated by relatively few species would have a high value and may indicate environmental stress. The percent Dominant Taxa ranged from 19 at location 5 to 40 at location 3 (Table 6). Ranking of locations from lowest to highest water quality as suggested by the percent Dominant Taxa values is as follows: 3<2<4<6<1<5.

The Community Loss Index measures the loss of benthic species between a reference station and the station of comparison. Each location adjacent to and downstream of the site was compared to the upstream reference locations. Potential values range from 0 to infinity, with lower values indicating a higher degree of similarity; higher values indicate less similarity, or a loss of taxa common to the compared communities. The Community Loss Index ranged from 0.20 at location 5 to 0.81 at location 2 when compared to reference location 1 (Table 6). A ranking of locations from most to least similar to reference location 1 is as follows: 5, 3, 6, 4, 2. The Community Loss Index ranged from 0.17 at location 1 to 0.28 at location 4 when compared to reference location 2 (Table 6). A ranking of locations from most to least similar to reference location 2 is as follows: 1=3=5, 6, 4.

3.3.1.4 Comparison

Community metrics, including taxonomic richness, the HBI index, the scraper/filterer ratio, EPT taxa, the EPT/Chironomidae ratio and percent contribution of dominant taxa, for each study location (locations 3 through 6) were compared to each reference location (locations 1 and 2). When compared to reference location 1, scores indicated a wide range of dissimilarities (Table 7). For example, the values obtained for the scraper/filterer ratio ranged from 8 percent at location 2 to 58 percent at location 5, suggesting a high degree of dissimilarity. In contrast, the range of values obtained for the modified HBI index ranged from 85 percent at location 3 to 101 percent at location 5, suggesting a high degree of similarity. When reference location 2 was used as a basis for comparison, the values obtained for all compared metrics were greatly in excess of 100 percent, again suggesting a high degree of dissimilarity (Table 7).

# TABLE 7. COMPARISON OF ROCKAWAY RIVER RIFFLE AREA MACROINVERTEBRATE COMMUNITY METRICS L.E. CARPENTER SITE WHARTON, NEW JERSEY SEPTEMBER 17-18, 1992

| Metric | Sample Location | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| **% Comparison to Reference Area 1** | | | | | | |
| Taxonomic Richness | 100 | 62 | 85 | 74 | 103 | 74 |
| HBI (modified) | 100 | 87 | 85 | 98 | 101 | 98 |
| Scraper/Filterer Ratio | 100 | 8 | 9 | 29 | 58 | 14 |
| EPT Taxa | 100 | 53 | 69 | 77 | 100 | 77 |
| EPT/Chironomidae Ratio | 100 | — | — | — | — | — |
| % Contribution (Dom. Taxa) | 100 | 69 | 63 | 76 | 132 | 93 |
| **% Comparison to Reference Area 2** | | | | | | |
| Taxonomic Richness | — | 100 | 138 | 119 | 166 | 119 |
| HBI (modified) | — | 100 | 97 | 113 | 116 | 113 |
| Scraper/Filterer Ratio | — | 100 | 125 | 375 | 738 | 175 |
| EPT Taxa | — | 100 | 129 | 143 | 186 | 143 |
| EPT/Chironomidae Ratio | — | 100 | 80 | 209 | 27 | 62 |
| % Contribution (Dom. Taxa) | — | 100 | 90 | 109 | 189 | 133 |

## BIOLOGICAL CONDITION SCORING CRITERIA

| Metric | Score | | | |
|---|---|---|---|---|
| | 6 | 4 | 2 | 0 |
| Taxonomic Richness | >80% | 60-80% | 40-60% | <40% |
| HBI (Modified) | >85% | 70-85% | 50-70% | <50% |
| Scraper/Filterer Ratio | >50% | 35-50% | 50-35% | <20% |
| EPT Taxa | >90% | 80-90% | 70-80% | <70% |
| EPT/Chironomidae Ratio | >75% | 50-75% | 25-50% | <25% |
| % Contribution (Dom. Taxa) | <20% | 20-30% | 30-40% | >40% |

The community metrics discussed above were assigned a biological condition score as a fraction of the percent comparison (Table 7) and tabulated to determine a bioassessment conclusion (Table 8). When compared to reference location 1, the bioassessment indicates location 2 was moderately impaired, locations 3, 4, and 6 were slightly impaired, and location 5 was non-impaired. When reference location 2 was used as a basis for comparison, all locations were non-impaired.

### 3.3.2 Coarse Particulate Organic Matter Community

#### 3.3.2.1 Community Structure

A total of 27 taxonomic groups were collected from coarse particulate organic matter of the Rockaway River (Table 9). Of these, 1 was a Mollusc, 1 was an Oligochaete, 1 was a Tubellarian, 4 were Crustaceans, and 20 were Insects. The number of taxa collected ranged from 6 at location 4 to 13 at location 6.

There was not a dominant group, in terms of taxonomic diversity. The Coleopterans, Dipterans, and Crustaceans were represented by 4 taxa each. However, the Coleopterian taxa, including *Microcylloepus*, *Stenelmis*, and *Helichus*, were collected from only one location each. In contrast, the Dipteran and Crustacean taxa were more cosmopolitan in distribution; two Dipterian and one Crustacean taxa were collected from at least five locations. Although only three Ephemeropteran taxa were collected, they were represented by at least two taxa at every location. *Isonychia* was the only taxa present at every location in the Rockaway River.

The Crustacean *Gammarus* was the numerically dominant taxa present in the coarse particulate organic matter samples Although not collected at location 1, and present in few numbers at location 2, it was the most numerically abundant organism at locations 3, 4, and 5 where it represented approximately 36, 90, and 74 percent of the individuals collected, respectively. Other taxa, including Simuliidae, Chironomidae, and to a lessor extent *Baetis*, and *Hydropsyche*, were present at some locations in significant proportions. It is interesting to note that *Hyalella* was the numerically dominant organism at location 1 and is ecologically equivalent to *Gammarus*, which was numerically dominant at locations 3, 4 and 5. No organisms, with the exception of *Isonychia*, were consistently observed at all sampling locations.

Most taxa followed variable distribution patterns and were infrequently collected. Of the 27 taxa collected, 14 were present at only 1 location, 4 were present at 2 locations, 3 at 3 locations, 2 at 4 locations, 3 at 5 locations and 1 at 6 locations. Further most taxa were collected in low numbers. For example, of the 60 records of taxa occurrences, 22 were for solitary individuals, 9 were for 2 individuals, and 5 were for 3 individuals. Hence 60 percent of the records were for 3 or fewer individuals.

**TABLE 8. BIOLOGICAL CONDITION SCORES AND BIOASSESSMENT CONCLUSIONS FOR THE RIFFLE AREA MACROINVERTEBRATE COMMUNITY OF THE ROCKAWAY RIVER**
**L.E. CARPENTER SITE**
**WHARTON, NEW JERSEY**
**SEPTEMBER 18-19, 1992**

| Metric | Sample Location | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| **% Comparison to Reference Location 1** | | | | | | |
| Taxonomic Richness | 6 | 4 | 6 | 4 | 6 | 4 |
| HBI (modified) | 6 | 6 | 6 | 6 | 6 | 6 |
| Scraper/Filterer Ratio | 6 | 0 | 0 | 2 | 6 | 0 |
| EPT Taxa | 6 | 0 | 0 | 2 | 6 | 2 |
| EPT/Chironomidae Ratio | ---- | ---- | ---- | ---- | ---- | ---- |
| % Contribution (Dom. Taxa) | 4 | 2 | 2 | 2 | 6 | 4 |
| Community Loss | 6 | 4 | 6 | 6 | 6 | 6 |
| Total | 34 | 16 | 20 | 22 | 36 | 22 |
| % Comparison to Reference | ---- | 47 | 60 | 65 | 105 | 65 |
| Bioassessment | | Moderately Impaired | Slightly Impaired | Slightly Impaired | Non-Impaired | Slightly Impaired |
| **% Comparison to Reference Location 2** | | | | | | |
| Taxonomic Richness | ---- | 6 | 6 | 6 | 6 | 6 |
| HBI (modified) | ---- | 6 | 6 | 6 | 6 | 6 |
| Scraper/Filterer Ratio | ---- | 6 | 6 | 6 | 6 | 6 |
| EPT Taxa | ---- | 6 | 6 | 6 | 6 | 6 |
| EPT/Chironomidae Ratio | ---- | 6 | 6 | 6 | 2 | 4 |
| % Contribution (Dom. Taxa) | ---- | 2 | 2 | 2 | 6 | 4 |
| Community Loss | 0 | 6 | 6 | 6 | 6 | 6 |
| Total | ---- | 38 | 38 | 38 | 38 | 38 |
| % Comparison to Reference | ---- | ---- | 100 | 100 | 100 | 100 |
| Bioassessment | | | Non-Impaired | Non-Impaired | Non-Impaired | Non-Impaired |

## TABLE 8 (cont'd). BIOLOGICAL CONDITION SCORES AND BIOASSESSMENT CONCLUSIONS FOR THE RIFFLE AREA MACROINVERTEBRATE COMMUNITY OF THE ROCKAWAY RIVER L.E. CARPENTER SITE WHARTON, NEW JERSEY SEPTEMBER 18-19, 1992

### BIOASSESSMENT CONDITION CATEGORY

| % Comparison to Reference | Category | Attributes |
|---|---|---|
| >83% | Non-impaired | Comparable to the best situation to be expected within an ecoregion. Balanced trophic structure. Optimum community structure (composition and dominance) for stream size and habitat quality. |
| 54-79% | Slightly impaired | Community structure less than expected. Composition (species richness) lower than expected due to loss of some intolerant forms. Percent contribution of tolerant former increases. |
| 21-50% | Moderately impaired | Fewer species due to loss of most intolerant forms. Reduction in EPT index. |
| <17% | Severely impaired | Few species present. If high densities of organisms, then dominated by one or two taxa. |

**TABLE 9. MACROINVERTEBRATES COLLECTED FROM COARSE PARTICULATE ORGANIC MATTER OF THE ROCKAWAY RIVER L.E. CARPENTER SITE WHARTON, NEW JERSEY SEPTEMBER 18-19, 1992**

| Taxa | Sample Location | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| EPHEMEROPTERA | | | | | | |
| *Isonychia* | 1 | 1 | 6 | 1 | 2 | 1 |
| *Baetis* | 2 | 24 | 2 | | | |
| *Stenonema* | | | | 3 | 3 | 5 |
| ODONATA | | | | | | |
| *Progomphus* | | | | | 1 | |
| PLECOPTERA | | | | | | |
| *Acroneuria* | | | | | | 1 |
| *Paragnetina* | 1 | | 2 | | 1 | 4 |
| TRICOPTERA | | | | | | |
| *Chimarra* | 1 | | | 9 | | 2 |
| *Lype* | | | | | 1 | |
| *Hydropsyche* | 3 | 20 | 1 | | | 1 |
| *Oecetis* | | | 1 | | | |
| LEPIDOPTERA | | | | | | |
| *Acentria* | | 1 | | | | |
| *Paraponynx* | | 1 | | | | |
| COLEOPTERA | | | | | | |
| *Macronychus* | | | 3 | | | 1 |
| *Microcylloepus* | | | | | | 1 |
| *Stenelmis* | 1 | | | | | |
| *Helichus* | | | | | | 1 |
| DIPTERA | | | | | | |
| *Antocha* | 9 | | | | | |
| *Tipula* | 8 | | | | | |
| Simulidae | 10 | 5 | 14 | | 1 | 5 |
| Chironomidae | 17 | 48 | 4 | | 4 | 16 |
| MOLLUSCA | | | | | | |
| *Goniobasis* | | | 4 | | | |
| CRUSTACEA | | | | | | |
| *Orconectes* | | | | 1 | | |
| *Gammarus* | | 3 | 22 | 148 | 40 | 11 |
| *Hyalella* | 18 | | | | | |
| *Caecidotea* | | | | 2 | | 2 |
| OLIGOCHAETA | | | | | | |
| *Species 1* | | 2 | | | 1 | |
| TRICIADIDA | | | | | | |
| Planariidae | | 9 | 2 | | | |

3.3.2.2 Community Function

Six functional feeding groups were observed in coarse particulate organic matter collected from the Rockaway River (Table 10). Filterers, gatherers, and omnivores were the dominant groups and were collected from all locations. Representation of filterers ranged from 7 percent at locations 4 and 5 to 34 percent at location 3. Gatherers ranged in representation from 15 percent at location 2 to 92 percent at location 4. Omnivores ranged in representation from 1 percent at location 4 to 50 percent at location 2. Scrapers and predators (with the exception of location 4) were present in low numbers at all locations were they represented less than 11 percent the community. Shredders represented 6 percent of the community at location 1 and were not collected at any other location.

A distinct trend was observed in the relative distribution of filterer, gatherer, and omnivorous functional feeding groups among locations. Dominance of a particular feeding group was generally a function of the numerical abundance of one or two taxa rather than an overall trend in most taxa present at any one location. For example, gatherers dominated the community at locations 1, 3, 4, and 5. This group was represented primarily by *Hyalella* and *Antocha* at location 1 and by *Gammarus* at locations 3, 4 and 5. Further, the dominance at subsequent locations did not follow a consistent trend, but rather appears to be random.

3.3.2.3 Metrics

The number of taxa collected at a single location ranged from 6 at location 4 to 13 at location 6 (Table 11). Ranking of locations from lowest to highest water quality as suggested by taxa richness is as follows: $4<5<2<1=3<6$.

The abundance of the shredder functional feeding group relative to the abundance of all other groups combined allows an evaluation of potential impairment as indicated by the CPOM-based shredder community. The shredder abundance ratio for location 1 was 9; this ratio was not calculated for locations 2 through 6 due the absence of shredders at these locations.

## 3.4 Periphyton

The periphyton community was qualitatively evaluated for the presence and relative abundance of major components (Table 12). The unicellular and filamentous green algae were frequently observed and were abundant or common at most locations. Diatoms were also collected at all locations but were most abundant at locations 1, 2, and 3. Blue-green algae were rare, but observed at all locations. Fungi and microarthropods were not observed at all locations and were rare when observed.

TABLE 10. PERCENT COMPOSITION BY FUNCTIONAL FEEDING GROUPS(1) OF BENTHIC MACROINVERTEBRATES COLLECTED FROM CPOM OF THE ROCKAWAY RIVER
L.E. CARPENTER SITE
WHARTON, NEW JERSEY
SEPTEMBER 18-19, 1992

| Group | Sample Location | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Shredders | 6 | 0 | 0 | 0 | 0 | 0 |
| Collector-filterers | 21 | 23 | 34 | 7 | 7 | 18 |
| Collector-gatherers | 46 | 15 | 40 | 92 | 80 | 33 |
| Scrapers | 2 | 10 | 11 | 1 | 3 | 8 |
| Predators | 1 | 2 | 5 | 0 | 4 | 10 |
| Omnivores | 24 | 50 | 10 | 1 | 7 | 31 |

(1) Modified from Merrit and Cummins, 1984.

**TABLE 11. METRIC VALUES FOR THE MACROINVERTEBRATE COMMUNITY COLLECTED FROM CPOM OF THE ROCKAWAY RIVER L.E. CARPENTER SITE WHARTON, NEW JERSEY SEPTEMBER 17-18, 1992**

| Metric | Sample Location | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Taxonomic Richness | 11 | 10 | 11 | 6 | 9 | 13 |
| Numeric Abundance | 71 | 114 | 61 | 164 | 54 | 51 |
| Shredder/Abundance Ratio | 9 | 0 | 0 | 0 | 0 | 0 |

**TABLE 12. SUMMARY OF PERIPHYTON COMMUNITY COLLECTED FROM THE ROCKAWAY RIVER L.E. CARPENTER SITE WHARTON, NEW JERSEY SEPTEMBER 17-18, 1992**

| Community Component | Sample Location | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| Blue green | R | R | R | R | R | R |
| Unicellular green | A | C | A | C | A | A |
| Filamentous green | C | C | C | C | R | N |
| Diatoms | C | C | C | R | R | R |
| Fungi | R | N | N | N | R | R |
| Microarthropods | R | R | N | N | N | N |

A - Abundant
C - Common
R - Rare
N - Not Observed

WESTON
MANAGERS DESIGNERS/CONSULTANTS

## 4.0 DISCUSSION

The ecological assessment of the Rockaway River consists of various components that, when viewed independently offer little insight to characteristics of the study area. However when habitat, as the principal determinant of biological potential, sets the stage for an integrated evaluation, several trends are evident. These are presented here in summary fashion and discussed in more detail in the sections that follow.

The riparian habitat of the Rockaway River in the vicinity of the L.E. Carpenter Site is variable in nature and includes forested flats, industrial and commercial facilities, and residential developments.

The aquatic habitat of the Rockaway River in the vicinity of the L.E. Carpenter Site is also variable in nature and includes a manmade pond, heavily braided wetland channel, riffle, run, and pool sequences that have been modified to favor trout production, and substrate altered by historic mining activities.

Individual organisms and species respond to all habitat variables resulting in a community of organisms adapted to a particular space and time. The following trends were observed in the study area:

The community at reference location 1 is codominated by filterers, gatherers, and scrapers, in response to available food resources and available habitat.

The community at locations 2 and 3 is dominated by filterers in response to the increased load of suspended materials released by Washington Forge Pond.

The community at locations 4 and 5 were codominated as at location 1 but with a slightly higher percentage of gatherers. This may be in response to a deposition of suspended materials at these locations.

Filterers dominated at location 6. (Error in Table 5)

Dominant community elements were present at all locations in the study area but differed in relative numeric abundance in response to varying habitat components.

The macroinvertebrate community of the Rockaway River was not impaired at locations adjacent to or downstream of the L.E. Carpenter Site. The community at these locations was similar to other locations in terms of composition; the relative abundance of community elements was consistent with the reference locations outside of potential effects, as well as stream ecosystem theory.

The overall assessment of ecological condition first focuses on the evaluation of habitat quality, and secondly on the analysis of biological components in light of these data. Habitat, as the principal determinant of biological potential, sets the stage for interpreting biosurvey data and can be used as a general predictor of biological condition. The attainable biological potential of a stream or river is primarily determined by the quality of the habitat at a particular location. Good quality habitat will support high quality biological communities and responses to minor alterations will be subtle and of little consequence. However, as a habitat declines in quality, discernable biological impairment results. When habitat and biological data are systematically collected together, empirical relationships can be quantified and subsequently used for screening impact and discriminating water quality impacts from habitat degradation.

The productivity of flowing waters are directly related to the watershed within which they flow. Much of the energy utilized within stream ecosystems is fixed in the surrounding terrestrial environment and transported to the stream in the form of particulate and dissolved organic matter. Primary and secondary productivity that occurs within a stream is directly related to nutrients derived from the watershed. The Rockaway River watershed drainage has been modified as a result of past and present land use, particularly with respect to residential developments, the siting of commercial and industrial facilities, and historic mining activities. As a result of these activities, the quality and quantity of terrestrial materials entering the Rockaway River has been altered. For example, the loss of riparian vegetation through replacement by turf and ornamental species, and by paved surfaces has several consequences that affected the distribution of benthic macroinvertebrates. First, the loss of a proximal source of coarse particulate organic matter is directly related to an absence or reduction in shredding organisms, and other consumers in subsequent and dependent feeding groups. Second, sedimentation is a water and habitat quality degrading factor resulting from erosion of exposed soil. In smaller streams, such as the Rockaway River, erosion will increase turbidity and may result in reduced dissolved oxygen levels due to the oxygen demand of the degradable component of the eroded material. Additionally, turbidity will limit light penetration, negatively affecting primary productivity and its contribution to dissolved oxygen levels. Eroded materials can also negatively effect the stream habitat by scouring during the transport process. Larger components of the eroded material are transported in the bedload sediment discharge that moves along the channel bottom and often accounts for a major portion of the total load. It, along with the suspended load, may dislodge or otherwise disturb the benthic community. Following transport, the eroded materials settle to the streambed and become entrained in the interstitial spaces and crevices utilized by benthic macroinvertebrates. This can bury and suffocate relatively immobile benthic macroinvertebrates. This was observed in parts of the study area; in particular, at locations 3, 4 and 5, boulders were imbedded in eroded materials present in the stream channel.

River systems exhibit a continuous gradient of conditions, and biological systems respond to this gradient. Energy input, and the transport, storage and use of organic matter by macroinvertebrate functional feeding groups are largely regulated by the basin and are therefore somewhat predictable within a relatively small reach, such as that portion of the Rockaway River under investigation. Reference locations were established and used for comparison to areas adjacent to and downstream of the L.E. Carpenter Site. The downstream communities should, in the absence of stress, resemble the upstream reference communities within the framework of the River Continuum Concept (Vannote et al., 1980). The communities at downstream locations should be comprised of a similar assemblage of functional feeding groups, or an assemblage along the continua of intergrading and synchronized taxonomic replacements. The organisms at any one location are, therefore a function of the conditions at that location as well as the source of potential colonizing organisms in that region.

Reference location 1 is situated in a residential area with relatively low shading. This is likely to result in elevated autotrophic production by periphyton which contributes significantly to the energy budget of the Rockaway River. In addition, the transport of organic matter (produced both instream as well as in the forested riparian area) from upstream areas also contributes largely to the energetics of location 1. Subsequently, the community is dominated by scrapers, gatherers, and filterers. The former group exploits autotrophic production, whereas the latter groups exploit suspended and deposited organic matter produced in upstream areas. This distribution was reflected in the data generated in this investigation.

Reference location 2 is situated immediately downstream of Washington Forge Pond. Although the instream habitat is physically similar to location 1, the presence of the pond, and the somewhat degraded riparian habitat result in a significant change in the energetics at this and downstream locations. A pond, either manmade or natural, typically has significant effects on the downstream river. These include an increased plankton and bacterial content of the water, thermal stability, and flow equalization. The productivity of Washington Forge Pond is a function of nutrients derived from upstream and adjacent residential areas, as well as morphometric characteristics such as the relatively shallow depth. As evidenced by dense mats of vascular vegetation in the littoral zone as well as the turbid water, Washington Forge Pond is likely a nutrient enriched and highly productive waterbody. Along with epilimnetic water, high concentrations of plankton are likely to be discharged from the pond. Releases of this nature have been shown to have significant effects on stream benthos for as far as 6 kilometers downstream (Muller, 1956). In particular, filter feeding and deposit feeding organisms increase in abundance downstream of natural and manmade lakes and ponds (Muller, 1955; Tanaka, 1966; Anderson and Dicke, 1960; Ward, 1992) in response to the increased availability of resources.

The functional structure of the macroinvertebrate community at location 2, as well as locations downstream, were consistent with stream theory (Cummins, 1974 and Barbour and Cummins, 1989). At locations 2 and 3, filter feeding organisms comprised approximately 77 and 73 percent of the community, respectively. The dominant organisms included filter feeders such as *Isonychia*, *Cheumatopsyche*, *Hydropsyche*, and *Sphaerium*. Further downstream, at locations 4 and 5, detritus feeding organisms, including *Gammarus*, *Optioservus*, *Promoresia*, Chironomidae, and *Sphaerium*, increased in abundance. It is likely that the increase in deposit feeding and filter feeding organisms were not synchronized due to the relative availability of suspended material. Factors such as flow velocity and particle size determine settling velocity. It is possible that the velocity was insufficient at locations 4 and 5 to maintain a high suspended load and the material settled to the substrate. Further, the Rockaway River at locations 4 and 5 flows through a forested wetland that may provide a load of organic material that enters the detrital pool at these locations. Finally, the complex hydrology is likely to yield microhabitat characteristics that are depositional in nature, thus favoring deposit feeders. The filter feeding (i.e. collectors) organisms again dominated at location 6, but at a slightly reduced numbers relative to locations 2 and 3.

The macroinvertebrate community metrics summarize, in a single value, a particular component or characteristic of the community. The values can be interpreted in light of ecological theory and habitat data. The difference in the number of taxa at locations 1 and 2 is a function of the diversity and availability of food resources and available habitat. The habitats at these locations differ with respect to flow and substrate characteristics In particular, location 2 is subject to scouring and deposition immediately downstream of the dam apron and the riparian area is somewhat degraded. Habitat degradation of this type is likely to reduce in abundance potential inhabitants. However, it is likely that the readily available food resources is a major factor determining the dominant components of the aquatic community. With few exceptions, the dominant fauna at location 2 were also present at location 1, but in reduced numbers. The increase in taxa at locations further downstream was in response to the increase in the quality and diversity of the habitat. In particular, the diversity of flow characteristics, the degree of bottom scouring and deposition, and the stability of the riparian habitat in terms of vegetative cover increased in value.

The habitat at location 3 was awarded low value for embeddedness. The historic landuse in this area included mining and milling activities and remnants of the steel penstock are present along the southwestern corner of the site. The flume received flow from the main channel and confluences with the Rockaway River upstream of location 3. The boulders in the streambed at this location, and to a lessor extent at downstream locations, were embedded in a coarse sand that is likely to have been associated with mining activities. Additionally, the sand material, as well as the larger substrate materials were angular in shape, not smooth and rounded as typical for particles in a flowing water hydrosystem. This evidence of recent disturbance did not appear to inhibit the benthic community. Due to other limitations of the habitat at this location (i.e., embeddedness, bottom scouring/deposition) it is not likely that taxonomic richness would be greater in the absence of historic disturbance.

The macroinvertebrate community of the Rockaway River adjacent to and downstream of the site was compared to the reference communities. When reference location 1 was used, the downstream communities earned different scores for almost all categories. These results are expected due to differences in the habitats and their inherent abilities to sustain distinctly different biological communities. The energetic basis of the aquatic ecosystems downstream of the dam were driven primarily by suspended components produced in and discharged from Washington Forge Pond. The nature of that material (i.e.; plankton) in concert with the quality of the available habitat, formed the framework for the development of a community dominated by filter feeders. The differences, emphasized by the analyses, between location 1 and the downstream locations (in particular locations 2, 3, and 4), were the result of habitat and energetics.

When location 2 was used as the reference, the communities at locations 3, 4, 5 and 6 earned equivalent or higher bioassessment scores. The energetic base of these locations was similar to the reference and differences in scores were the result of habitat variabilities. Habitat scores increased from location 2 to location 6 primarily due to increased riparian stability. Consequently, the scores earned and the bioassessment conclusions indicated that these locations have not been impaired.

As discussed above, the distribution and abundance of benthic macroinvertebrates can generally be related to habitat considerations. However, the objective of this investigation was to determine if contaminants potentially present in Rockaway River sediment in the vicinity of the L.E. Carpenter Site are resulting in an adverse ecological effect. Benthic macroinvertebrates live on and in the sediment and are potentially exposed to any water and sediment contaminant burden if present. Toxicity of either phase would be evident in the community data collected. The biological community observed was consistent with the habitat described and ecological theory and evidence of impairment was not observed. The data suggest that the biological communities have not been, and are not being, impacted by the L.E. Carpenter Site.

## 5.0 CONCLUSION

The structure of the benthic macroinvertebrate community of the Rockaway River was quantified in terms of taxonomic diversity, numerical abundance, and function and was evaluated in light of biotic and abiotic environmental variables. Biotic variables included food availability, while abiotic variables included substrate particle size, riparian stability and vegetation and flow characteristics. The study indicated that the chief deterministic factors driving the distribution and abundance of benthic macroinvertebrates in the study area is the quality of the habitat as it relates to resource availability. The structural variations in the Rockaway River benthic macroinvertebrate community were most pronounced downstream of Washington Forge Pond and were primarily due to an increase in suspended planktonic matter released from the pond. At locations progressively further downstream, a shift in taxonomic and functional dominance was observed. Evidence of adverse ecological effects resulting from contaminants detected in the sediment were not observed in the Rockaway River adjacent to the L.E. Carpenter Site or in any portion of the Rockaway River studied. The historical operations on-site and current conditions of the site are not impacting the biological community in the sediment or water environments of the Rockaway River.

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